

Sensitive Detection of Radioactive Materials

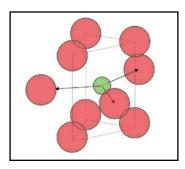
Special nuclear material that could be used for a nuclear weapon—such as highly enriched uranium or plutonium—is only weakly radioactive and easily shielded by common materials. Radioactive material for a dirty bomb is also tricky to detect, as it must be distinguished from legitimate sources such as medical isotopes. Given the sheer scale of daily traffic crossing U.S. borders, the detection challenge is monumental, particularly as inspection procedures must keep pace with the normal flow of commerce. Radiation detection systems must be fast, accurate, affordable, and protect operators from exposure to harmful levels of radiation.

With decades of experience securing the nation's nuclear stockpile, Sandia offers a wealth of expertise for improving radiation detection capabilities. Our Engineered Materials Department is developing advanced materials for more sensitive detection of gamma rays and neutrons. We are also engineering practical detection systems for use in homeland security and nuclear nonproliferation applications.

Lanthanide Halide Scintillators

When it comes to detecting gamma rays, lanthanide halides offer sharper resolution and faster response

Lanthanum halide crystals could revolutionize gamma ray scintillation spectroscopy—if the brittle crystals can be grown to sufficient size. This figure shows the LaBr₃ crystal structure in a polygon representation, depicting the central La in green and the nearest bromine

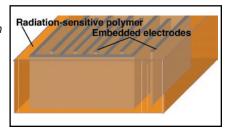


atoms in red. Our group is identifying the causes of structural imperfections and failure, and developing optimal processing strategies for large-crystal growth. than conventional sodium iodide scintillators. However. La-halide crystals are highly brittle and difficult to grow to the needed size. We are evaluating the thermo-mechanical properties of halide crystals to eliminate sources of stress-induced cracking. Smallscale characterization experiments are determining critical physical parameters, purification requirements, and crucible materials compatibility. We are examining commercially available samples for light yield, optical properties, mechanical defects (dislocations, stacking faults, internal boundaries, micro-cracks), and structureproperty relationships. We are also evaluating yield and fracture stress vs. temperature to determine ductile and brittle regimes. The project will support a constitutive model for mechanical behavior to guide refinements to crystal growth processes.

Organic Semiconductors

Typical systems for detecting fission-spectrum neutrons rely on elastic scattering in organic scintillators. This method provides large signals for high-energy neutrons, but does not work well for lower-energy applications such as passive imaging of shielded, highly enriched uranium (HEU).

An organic semiconductor detection element—shown here in conceptual design—could enable passive screening of shielded HEU.



We are investigating a different approach: direct electronic detection using organic semiconductors. Semiconducting materials would eliminate the need for optics and vacuum tubes, and could enable high-spatial-resolution imaging, particle tracking, recoil collimation, and gamma rejection. Yet large improvements in the semiconducting properties of organic materials must be realized. We are working to increase charge transport by inducing long-range ordering of polymer chains





through novel synthesis and processing techniques. This innovation will significantly enhance signal collection in organic semiconductors, enabling bulk devices with the dimensions required for practical neutron detection and imaging applications.

Backpack-Portable Detection System

Weighing less than 20 pounds, our battery-operated neutron generator will be able to search for concealed fissionable material under diverse field scenarios. Design specifications call for an alpha-emitting radioisotope and a beryllium target to create neutrons with a flux of ~106 n/s via the $9Be(\alpha,n)$ reaction. A rotational motor moves the alpha-emitting and Be plates in and out of alignment, turning neutron production on and off at rates from 100 to 1000 Hz. The generator is designed for very low emissions in the "off" state, with substantial safety features to ensure user protection. The alpha-beryllium reaction produces neutrons with energies from thermal to 10 MeV, with an average energy of 4.5 MeV.

Monochromatic Gamma Tube for Low-Dose Interrogation

In collaboration with Lawrence Berkeley National Laboratory, we are developing an advanced monochromatic photon source for low-dose photofission interrogation of heavily shielded SNM. Mono-energetic gamma rays enable a much lower interrogation dose (~1/1000 the dose of broadband sources) to obtain the same detected HEU signal. The gamma tube will operate in either continuous or pulsed modes and is scalable to high-flux operation, a feature unique to low-energy accelerators.



Using monochromatic gamma rays, this axial gamma tube and power supply (shown here in prototype) is designed to interrogate shipping containers within acceptable dose limits.

Materials and Techniques for Active Interrogation

In parallel with the gamma tube system development, we conduct basic research using a lab-based ion accelerator to obtain key data for photon-based active interrogation. In particular, experiments identify proton-target configurations that maximize the gamma yield



Ion accelerator laboratory

and materials that can withstand the harsh thermal and radiation environments inside an operational gamma tube. The accelerator-based photofission experiments provide data to maximize the induced fission signals from special nuclear material while distinguishing these signals from the background radiation arising from other sources.

Neutrons from Electric Field Desorption

To satisfy unmet field requirements, we are developing a neutron generator based upon a unique concept for the ion source: using high electrostatic fields to form pure atomic deuterium ion beams as a result of electrostatic field desorption (EFD) from an array of conductive microfabricated tips. Advantages include scalable neutron output, reasonable cost, elimination of thermal engineering challenges, dramatically lower power consumption, and lifetimes exceeding 1000 hours. The EFD ion source offers versatile application, from man-portable systems to large, fixed scanners.

Data Analysis for Radiologic Alerts

The Department of Homeland Security deploys radiation portal monitors at numerous border crossings. If a radiation alarm is difficult to characterize, Sandia provides callback assistance. Our extensive data mining and analysis tools afford rapid access to archival data generated by the portal monitors, enabling trending and analysis of specific commodities.

Learn more at: http://public.ca.sandia.gov/8700